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From Traditional Product Lifecycle Management Systems to Blockchain-Based Platforms

Mubashir Hayat * and Herwig Winkler *

Chair of Production and Operations Management, Brandenburg University of Technology, 03046 Cottbus, Germany

* Correspondence: mubashir.hayat@b-tu.de (M.H.); winkler@b-tu.de (H.W.)

Abstract: *Background:* Several product lifecycle management systems (PLMs) have been implemented in the industrial sector for managing the data of the product from the design up to the disposal or recycling stage. However, these PLMs face certain challenges in managing the complex and decentralized product lifecycles. *Methods:* To this aim, this work investigates the currently implemented PLMs used in industries through the exploration of various software reviews and selection websites. Accordingly, these existing PLMs are quantitatively compared and analyzed. *Results:* The analysis shows that most of the existing PLMs do not contain all the required features; therefore, industries integrate different software to create a full-fledged PLM system. However, this practice results in reducing the overall system efficiency. In this context, this paper assesses and recommends a blockchain-based innovative solution that overcomes the challenges of existing PLMs, hence increasing the overall system efficiency. Furthermore, this work argues, in a logical way, that the recommended blockchain-based platform provides a secure and connected infrastructure for data handling, processing, and storage at different stages of the product lifecycle. *Conclusions:* This work can be considered among the first to compare the currently implemented PLMs with a novel blockchain-based method. Thus, the stakeholders can utilize the outputs of this research in their analysis and decision-making processes for implementing the blockchain in their organizations.

Keywords: product lifecycle management; blockchain technology; product development; decentralization; production system

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1. Introduction

Product lifecycle management (PLM) is the process of data management that directs the entire lifecycle of a product, from inception to its ultimate disposal or retirement. The core requirement for the PLM in the production industry is data storage and ensuring its fast, easy, and trouble-free processing for intelligent decision making in product development. PLM involves different stages of the product lifecycle, including design, production, distribution, operations, and maintenance, as well as disposal or recycling. In today's market, PLM has become a tactical solution for improving product competitiveness in the industry [1]. To compete successfully, the industries are constantly trying to implement a system that can efficiently collect and store the product data in real-time at a series of stages of the product lifecycle. The more data are collected from each phase of the product lifecycle, the greater the potential for product development. However, managing this large amount of data generated at various stages is not an easy task, and hence requires a proper management system.

To this aim, several PLM systems have been implemented and used in different industries. These systems are developed using a centralized and standalone framework and are usually responsible for data collection and management locally in their domain. However, in today's cyber-physical age, the aim in the industries is not just the data collection, but the ability to connect the collected data in a sophisticated way that can easily be used for training the intelligent learning models. Simultaneously, the objective is to convert the data managed by the concerned personnel into the industry's capital in an easily manageable and shareable form [2]. In other words, work that has once been performed on the product at any time and phase shall remain exploitable. However, the existing systems are unable to allocate the data to the individually customized product. Therefore, there is a need to holistically gather the data generated at different stages so that it can be allocated to each product and concerned customer.

Furthermore, currently, product lifecycles are usually complex and decentralized in nature. Hence, the data need to be transparent and auditable so that every stakeholder has access and can exchange the data with all the associated parties. A new data management system needs to be implemented that can address and solve the data transparency and auditability challenges. For this purpose, blockchain, a shared and immutable ledger, can be used to facilitate the process of recording transactions and tracking assets in a business network [3]. In a blockchain, the transactions are recorded, protected, proofed, stored, and shared with all the participants of the chain. Hence, all the stakeholders can permanently exchange the data that are important from their perspectives. In comparison to the traditional PLM approaches, a blockchain has distinct characteristics, i.e., it is a secure, decentralized, and distributed ledger. Each member of the chain can access it from anywhere in the world using an internet connection, which leads to greater transparency and auditability. A blockchain allows the data to be tracked in an inviolable way, making it possible to go back through the entire history of the product lifecycle [4].

In this work, we aim to explore the currently implemented PLMs. These existing PLMs are quantitatively compared and analyzed regarding certain basic features and characteristics that are the core requirements of any system. Then, problems associated with those PLMs are highlighted and an alternative solution is presented that can solve these problems. In other words, this work is a systematic review that highlights and emphasizes the specific issues with data management and recommends a novel solution for those issues. For this purpose, the research questions that this paper aims to answer are:

- What are the currently implemented PLMs, and what features do those PLMs contain?
- Do blockchains address the same purpose and functionalities as those of existing PLMs?
- Why are blockchain-based platforms better and hence, recommended over the traditional PLMs?
- How does the proposed solution enhance the efficiency of the production system?

The rest of the paper is organized as follows: The currently implemented PLMs are explored and evaluated in Section 2. Section 3 provides the conceptual background and basics of the blockchain technology. The recommended blockchain-based platform is presented in Section 4. Section 5 consists of the discussion and benefits of the recommended platform. Finally, this work is summarized in Section 6.

2. Exploration of Traditional PLMs

During the exploration of various software reviews and selection websites, a total of 135 PLM systems currently implemented in industries have been determined. All of these 135 systems are deployed on-cloud; however, 23 of them provide on-premises services as well. The features of the software using both systems are the same; however, the difference is in the data storage policy. The on-cloud database is hosted on the vendor's server and can only be accessed through the web browser. While in the on-premises scenario, the software is installed on the industry's databases and servers so that the generated data are managed locally by the industry itself. A detailed quantitative comparison of existing PLMs in the industries is carried out and is provided in Appendix A. Some considerations that have been implemented during the process of exploration can be pointed out as:

- Depending upon the vendor, features, and size, the PLM systems are available in different price ranges. However, this survey considered PLMs of all price ranges.
- Different systems are suitable for use in different sized industries. However, we considered all PLMs, irrespective of their implementation in the respective industry.

- The supported language in most of the PLMs is English; however, some systems support other languages as well. This study considered PLM in all languages.
- Only those PLMs that contains at least three basic features are considered in the comparison.
- The type of production system in which these PLM are implemented, i.e., mass, batch, or job shop production is also ignored in this comparison.

It is observed from the data presented in Appendix A that most of the PLMs do not include all the required features; therefore, the software vendors usually offer a list of applications that may be integrated with each other to form a complete PLM system. However, in this case, data exchange would be slow and time-consuming. The time required for data conversion from one system to another becomes high, reducing overall system efficiency. Table 1 summarize the number of currently implemented PLMs that are capable of supporting specific basic features. In the literature, the existing research publications consider only a limited number of existing PLMs in their analysis and are unable to take all the available PLMs into account. Therefore, searching using internet search engines could be considered a more sophisticated method, and hence is used in our exploration process. Therefore, the data of Appendix A and Table 1 are based on our search using various search engines, i.e., SelectHub [5], G2 Business software and services [6], Software TestingHelp [7], Capterra [8], PAT Research [9], and Adam Enfroy [10]. Furthermore, as these search engines are usually amended and updated on a regular basis, exploration via these websites leads to the latest list of existing PLMs.

Table 1. Number of PLMs targeting specific features.

Features	Number of Capable PLMs	Number of Incapable PLMs
Change Management	57	34
Design Management	54	44
Document Management	24	51
Project Management	29	42
Product Data Management	78	101
Requirements Management	81	91
Quality and Compliance Management	111	84
Supplier Management	106	93

It is quite clear from Table 1 that document management is the feature that most of the existing PLMs carry (a total of 111 PLMs), while change management is the most challenging feature and is carried by the least number of PLMs (a total of 78 PLMs). In addition to the basic features of PLMs, as described earlier, some software also carries additional capabilities. Enriquez et al. considered some of the top PLM systems and evaluated extra features in those systems at different stages, i.e., from “design” up to “after-sales management,” as illustrated in Table 2 [11]. Furthermore, they also presented some of the applications that can be integrated into the respective PLM to achieve specific tasks.

In addition to the extra features mentioned in Table 2, these PLMs are also highly scalable. Hence, these systems have the ability to grow and manage the increasing needs and demands of the consumers. Furthermore, these top PLMs also focus on the appropriate use and governance of data that is being generated, collected, and shared by different stages.

Table 2. Extra features included in top PLMs [11] "Adopted with permission from Enriquez et al. (2018). Copyright © 2018 Elsevier".

Extra Features	Enovia	Teamcenter	Windchill	CATIA	ARAS	Oracle
Design						
Compliance, environment, health and safety management	Yes	Yes	Yes	Yes	Yes	Yes
Product analysis, validation, and simulation	Simulia	TecnoMatrix	PTC Creo	Yes	Yes	Yes
Authoring Tools: CAD, CAE, CAM, ECAD, CASE ...	CATIA/SW	NX/Sedge	PTC Creo	Yes	Yes	Yes
Multi-CAD management	Yes	Yes	Yes	Yes	Yes	Yes
Software development	Partially	Partially	No	Yes	Yes	Yes
Technical documentation	Yes	Yes	Yes	Yes	Yes	Yes
Technology planning	Partially	Partially	No	No	No	No
Production						
Digital manufacturing	Simulia	TecnoMatrix	No	Yes	Yes	No
PLC programming	Delmia	TecnoMatrix	No	Yes	No	No
Support/Use						
After-sales management	Partially	Partially	Partially	No	Yes	No
Marketing	3D Excite Mar	No	No	No	No	No
General						
Intellectual property management	Yes	Yes	Yes	Yes	Yes	Yes
Quality lifecycle management	Yes	Yes	Yes	Yes	Yes	Yes
Communities of practice	Yes	Yes	Yes	Yes	Yes	Yes
Infrastructure management	Yes	Yes	Yes	Yes	Yes	Yes
Distribution	Partially	Partially	No	No	Yes	Yes

3. Fundamentals of a Blockchain

A blockchain is a digital, decentralized, and immutable ledger maintained by different computer nodes that facilitate the process of recording transactions and tracking assets in a business network [3]. The transactions are recorded in a data format called "block" and added to a shared database in chronological order to form a chain [12,13]. The transaction data in the block is validated by all the nodes in the network before its addition and storage on the chain [14–16]. A simple structure of a blockchain consisting of linked blocks is illustrated in Figure 1. The first block is usually referred to as a genesis block, followed by other blocks [17]. Each block mainly consists of three metadata, i.e., the pointer or hash that connects it to the previous block, the timestamp that certifies the time at which the transaction takes place, and the transaction data. Hashing of each block makes the complete chain an immutable ledger, so that the blocks can only be added and not removed from the chain [18]. In this way, the data is recorded, protected, proofed, stored, and shared with all the participants of the chain, which is the basic concept of a blockchain.

In general, there are three types of blockchain networks: public, private, and consortium blockchains. Public blockchains are permissionless in nature, and are therefore open for anyone in the world to access, perform transactions, and participate in the consensus process [19]. The blockchain concept presented by Satoshi Nakamoto in 2008 is an example of a public chain [20]. Private blockchains are permissioned blockchains controlled by a single central authority. The central authority permits the nodes who can join and perform the transaction. Hyperledger fabric, hosted by the Linux Foundation, is an example of a private blockchain [21]. Consortium blockchains are also permissioned blockchains, but instead of a single authority, they are controlled by a group of preselected nodes [22]. Consortium blockchains are more decentralized compared to fully private blockchains, and hence provide higher security. The global shipping business network (GSBN), developed by CargoSmart, is an example of a blockchain consortium that aims to digitalize the shipping industry, allowing maritime industry operators to work more collaboratively.

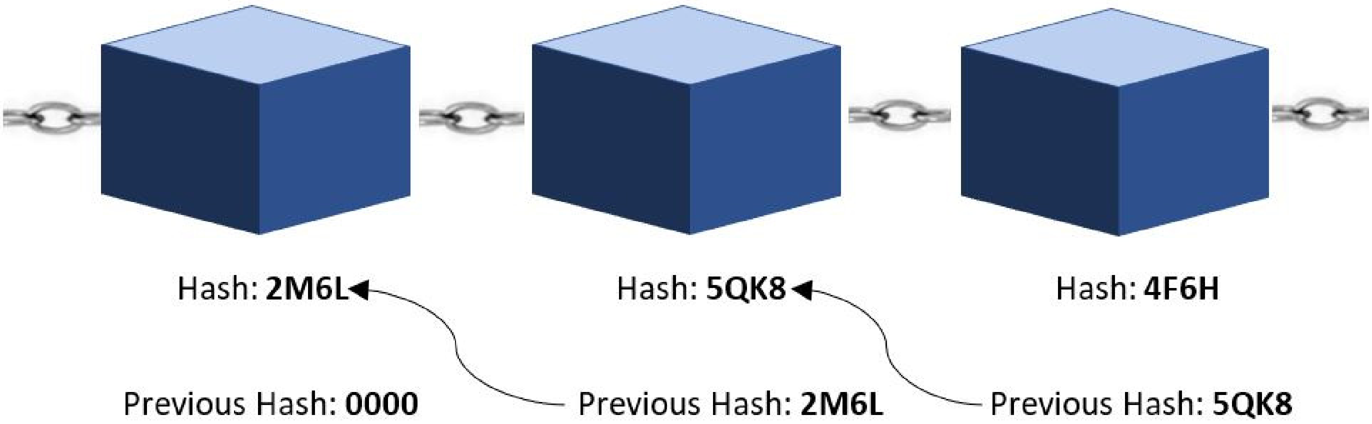

Figure 1. A structure of a blockchain consisting of linked blocks.

A blockchain is a digital platform that changes the way traditional databases store and record data and transactions [23]. In comparison to traditional ledgers, blockchains have distinct characteristics, i.e., they are secure, distributed, and decentralized in nature. Using an internet connection, each participant in the chain can access it from anywhere in the world, leading to greater transparency and auditability. A blockchain allows the data to be tracked in an inviolable way, making it possible to go back through the entire history of the product lifecycle. Hence, all the participants of the chain can permanently exchange information that is important from each perspective. Moreover, since all the permitted members of the network control each other, unlike in traditional ledgers, no intermediary or central point of account is needed [24]. A blockchain is more suitable to use in cases where the data requires clear identification and verifications. Furthermore, the use of blockchain technology is especially beneficial in the case of high value products with low trading volume [25].

Currently, an increasing number of initiatives in the blockchain are altering the traditional approaches in each sector. However, most of the research work available on blockchains focuses on cryptocurrency, i.e., over 80% of the research articles on blockchains are based on crypto, while less than 20% target other blockchain applications [26]. Moreover, most of the current work on the blockchain in the real business environment is still in an early stage, i.e., at the concept or idea phase [27]. However, it is strongly expected by the experts that the blockchain will target every industry and significantly change the existing approaches [12,15,28]. According to the report by the Statista research department, published on March 18, 2022, investment in blockchain-based solutions is expected to reach almost $19 billion by 2024 (https://www.statista.com/statistics/800426; accessed on 20 April 2022). Blockchains would be able to track $2 trillion worth of tangible and intangible goods in their supply across the globe by 2023, and accordingly, it will be an over $3 trillion business by 2030 [29].

4. Conceptualization of a Blockchain-Based Architecture

In this section, we present the concept of a blockchain-based platform that can be considered as a novel solution to the challenges faced by the existing PLMs. This platform contains all the basic and extra features of traditional PLMs. The conceptual framework for the proposed platform is shown in Figure 2. This platform connects all the phases of the product lifecycle from the design up to the disposal or recycling of any product; hence, the data can be visible and accessible to every stakeholder associated with the product throughout its lifecycle. Moreover, as the blockchain is an immutable ledger, the data in this presented platform would be secured and impossible to manipulate or forge. Hence, this can be considered a robust solution for safeguarding the data generated and shared among the stakeholders throughout the product lifecycle.

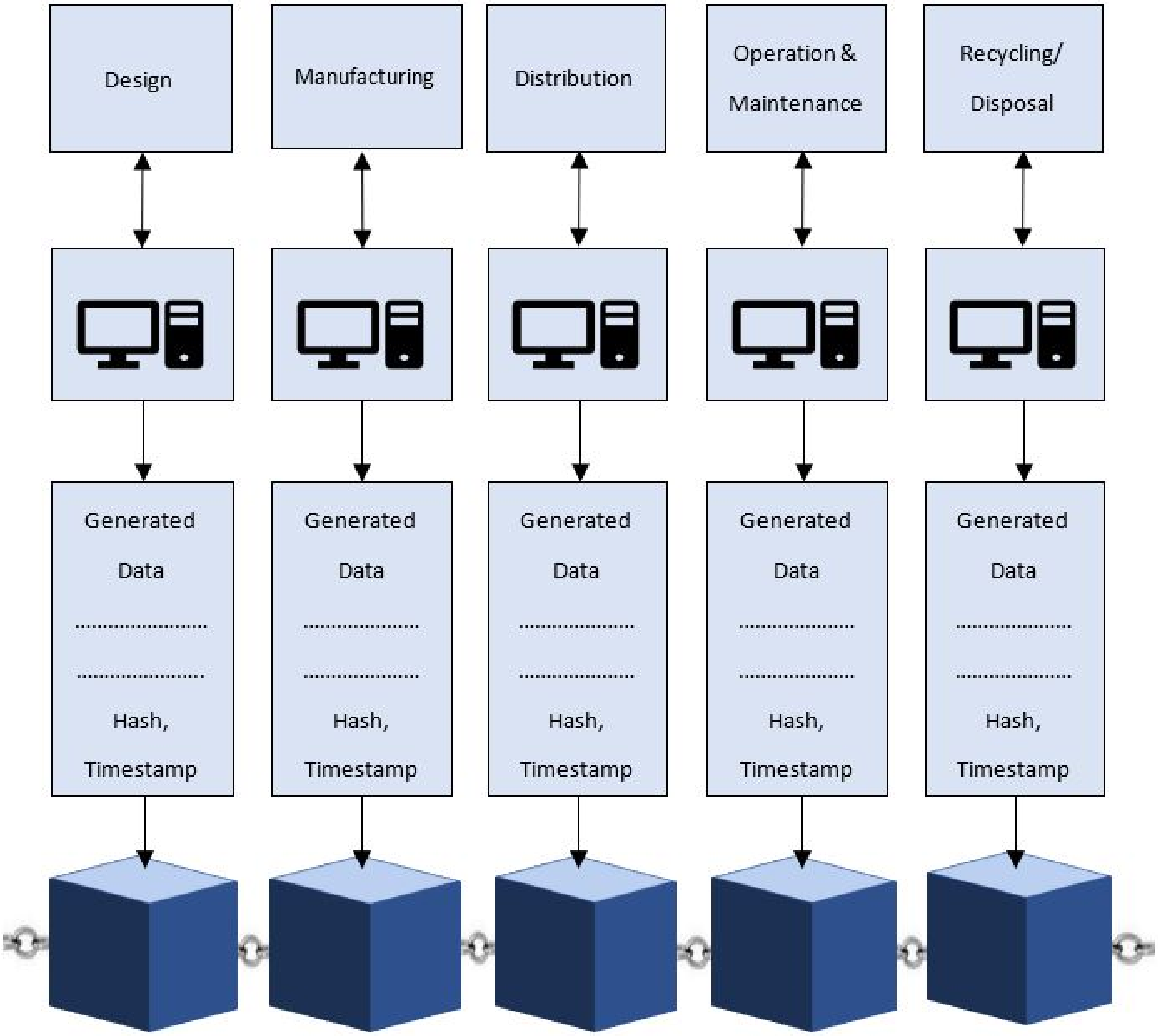

Figure 2. Conceptual Framework for a Blockchain-Based Platform.

The fundamental layers in this solution are similar to those of traditional PLMs, i.e., the physical and digital environment, digital data, and storage database. The physical environment consists of different stages of the product lifecycle where actual tasks are performed. The data generated through these tasks is converted to a digital form and stored in the database, which is blockchain-based, in this case. The data is validated by concerned nodes according to the defined protocols, and then it is stored and becomes part of the chain. This platform provides data access, along with advanced data analytics, to all stakeholders involved at different stages of the product lifecycle. Hence, all the stakeholders can permanently exchange the data from their perspectives.

Although the fundamental concepts in implementing blockchain technology in any industry are the same, as different industries may have different policies and working environments, every setup would require setting the basic strategies according to their own conditions. These strategies may be:

- Defining or choosing the suitable consensus protocols: A blockchain consensus protocol enables all the parties of the blockchain network to come to a common agreement on the present data state of the ledger. The business can define its own, or can choose from well-known available protocols. In case of the production industry, Byzantine fault tolerance, or crash fault tolerance, are the most commonly used consensus protocols.
- Selecting the suitable blockchain platform: Depending upon the chosen consensus protocols, industries can then select the most suitable blockchain platform. Many free and open-source blockchain platforms are available. In case of the production industry, the commonly used private blockchains are Hyperledger Fabric, Corda, and so on.
- Configurations of the blockchain instance: Blockchain platforms usually require very carefully planned configurations for different parameters. Some of these key parameters, i.e., permissions, hashes, block signatures, etc., can be configured and finalized by the individual businesses according to their own policies.

To clarify how the data generated at each stage is stored on the selected blockchain platform, we consider the manufacturing phase of the product lifecycle, as shown in Figure 3. In this stage, the raw material is processed through certain machines to create a finished product. The machines and processes in this stage depend on the type of manufacturing (conventional or additive), as well as on the type of product.

Initially, the data of raw material, i.e., its type, properties, suppliers, etc., are uploaded to the production database. During the manufacturing process at machine 1, all the information of the machine, materials, and process parameters are drawn up in a local database, digitally signed, and uploaded to the main production database by concerned personnel, such as the machine operator. The processed material is forwarded to the next machine as a work-in-process inventory for onward processing, and the same procedure of data generation, digital signature, and uploading is followed at machine 2, and so on. Once all the operations are performed and the production is completed, a complete production report is ready. The production manager checks to verify the data stored in the database and then hashes, timestamps, and shares them. Once the data are validated as per the consensus protocols, they then become part of the chain. The data of specific products and production processes in this specific phase of the product lifecycle are stored and become visible to all the stakeholders.

In this way, the block in this phase is created each time the production of a product is completed. In any blockchain platform, each block consists of two parts, i.e., the block header and the block body. In this phase, the block header has three elements, i.e., block version, timestamp, and a hash of the corresponding previous block. The block body in this phase caries the complete information of raw material, machines, processes parameters, as well as finished product data. The proposed blockchain-based platform is compared with the traditional PLMs, and the final results are given in Table 3.

The comparison in Table 3 summarizes that the blockchain-based platform contains all the features of the traditional PLMs. Moreover, the proposed platform also exhibits other unique characteristics that, in contrast, are challenges faced by traditional PLMs. Hence, we can use this blockchain-based platform to more securely and easily manage the data of products and create a bridge to link the data throughout its lifecycle.

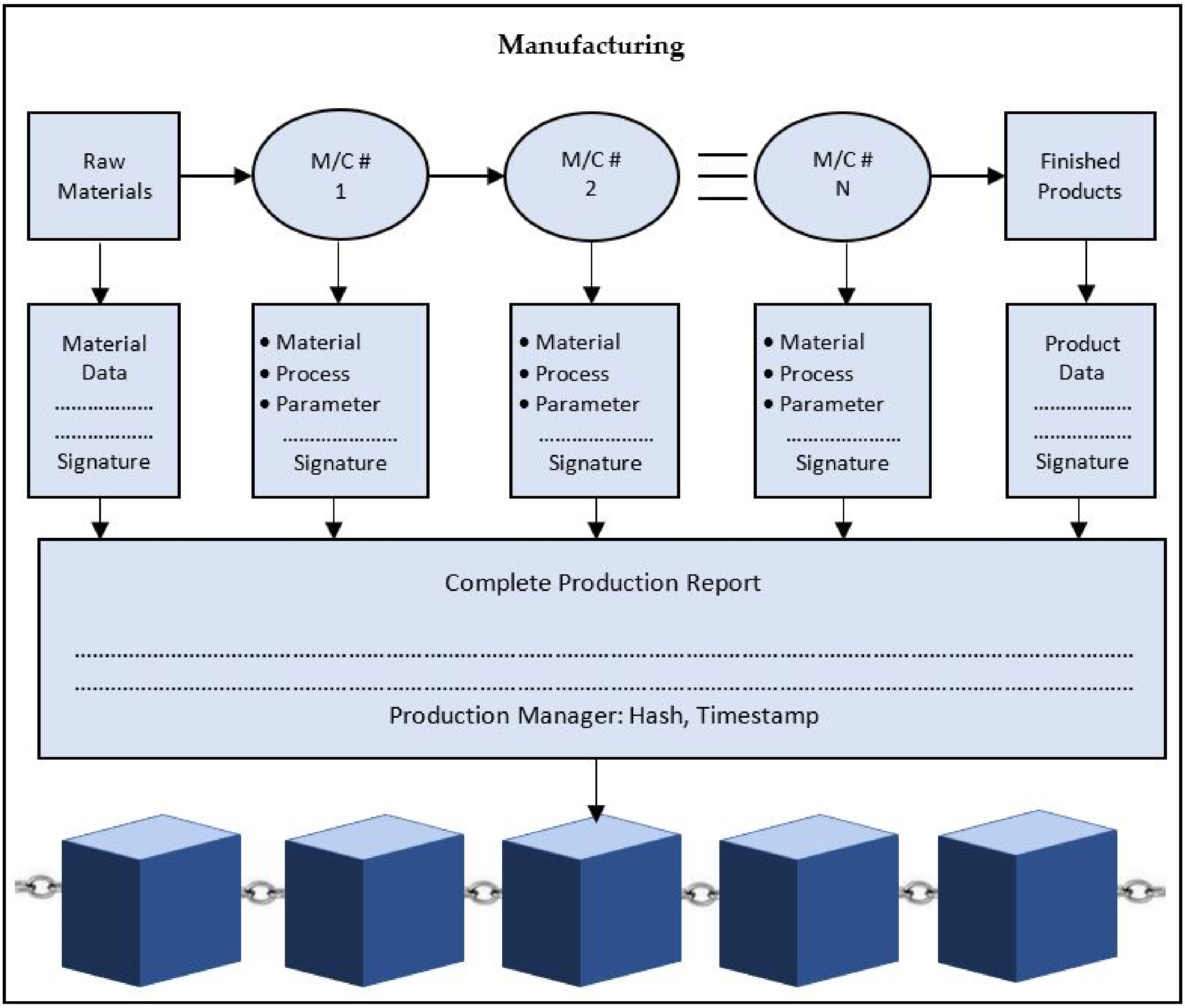

Figure 3. Data storage on the blockchain.

Table 3. Comparison between Traditional and Blockchain-Based PLMs.

Characteristics	On-Premises PLMs	On-Cloud PLMs	Blockchain-Based PLM
Basic Features (Table 1)	Yes	Yes	Yes
Extra Features (Table 2)	Yes	Yes	Yes
Interoperability	No	No	Yes
Data Transparency and Openness	No	No	Yes
Flexibility	No	Yes	Yes
Scalability	Yes	Yes	Yes
Decentralization	No	No	Yes
Software as a Service	No	Yes	Yes
Credibility	No	No	Yes
Big-Data Analytics	No	Yes	Yes
Ubiquitous Access	No	Yes	Yes
Collaborative Data Provision	No	No	Yes
Data Security	No	No	Yes

5. Discussion and Benefits of the Proposed Solution

Traditional PLMs, whether on-cloud or on-premises, offered by different vendors are centralized in nature and hence, face certain challenges in real-life production systems. Moreover, the quantitative comparison shows that most of these systems do not contain all the required features that a standard PLM tool should carry. Therefore, industries usually implement different PLMs and integrate them to create a complete PLM system. However, the data exchange between these different PLM tools is usually slow and time-consuming, reducing overall system efficiency. Additionally, due to the complex and decentralized nature of product lifecycles, the data needs to be transparent and auditable so that every stakeholder has access to and can exchange authentic data with all the other parties.

To meet all these requirements and features in a single system, we proposed a digital blockchain-based platform. This solution illustrates how various phases of the product lifecycle, from the design up to the disposal or recycling of any product, can be connected for data sharing. Through detailed elaboration, this paper determined that the proposed platform contains all the features of the traditional PLMs. Moreover, as illustrated in Table 3, this platform also has other distinct characteristics that the traditional PLMs lack. This study takes system-to-system shuffling into account and does not consider a specific blockchain-based platform. Therefore, in the near future, we can use any analytic technique, i.e., combined VIKOR-fuzzy AHP [30], to select among the available blockchain-based platforms. Once the specific blockchain-based platform is selected and implemented for PLM, we would then be able to compare the actual results with the previous studies, based on certain key performance indicators (KPIs). In addition to the features discussed in this paper, the KPIs could also be set for certain other dimensions, i.e., coercive and non-coercive drivers of sustainability [31], cleaner production [32], and so on.

Through the implementation of this platform, several benefits can be achieved in a real production environment. As the blockchain is an immutable ledger, the data in this presented platform would be secured and impossible to manipulate or forge. Hence, this model is considered to be a robust solution for safeguarding the data generated and shared among the stakeholders throughout the product lifecycle. This platform allows the data to be tracked in an inviolable way, making it possible to go back through the entire history of the product lifecycle. As the data is visible and accessible to every stakeholder associated with the product, it therefore provides an opportunity for a collaborative decision-making environment in product development. Hence, all the stakeholders can work continually on collaborative tasks throughout the product lifecycle. This collaborative environment results in:

- Better data management;
- Production agility and resiliency;
- Drive innovation;
- Improved production and performance;
- Continuity and traceability of information.

Real-time communication throughout different stages of the product lifecycle and data representation is of prime importance for planning and better decision making during product development. Therefore, this solution tends to reduce obstacles, creating an easy-to-communicate environment that is not possible through the use of centralized PLMs. All the blockchain platforms provide ubiquitous access, so they can be accessed from any device and any location with just an internet connection. This platform has specific attributes, i.e., availability, effectiveness, reliability, security, real-time, maintainability, and survivability, and hence it can be considered a highly credible system. Furthermore, large and intermittent data are usually generated in a complex and distributed product lifecycle, so the traditional PLMs sometimes face issues in handling such data. As the proposed solution is based on a distributed ledger, intermittent and large data can be easily handled and stored chronologically.

6. Conclusions and Future Directions

This work aims to explore and evaluate the currently implemented PLMs and accordingly recommends a novel platform to overcome the challenges faced by these PLMs. A total of 135 currently implemented PLMs and their associated features were identified through the exploration of various search engines, as given in Appendix A. Through the evaluation, it was observed that most of the existing systems do not contain all the required features; therefore, industries usually integrate different tools to create a full-fledged PLM system. However, this results in reducing overall system efficiency. Furthermore, we highlighted various challenges associated with these centralized PLMs in Table 3. Among these challenges, data security, transparency, and interoperability are the most important, since today's data management is not limited to a specific phase, but requires collaborative tasks. To succeed in these challenges, this paper emphasizes the need to adopt a novel technology for production industries.

Consequently, we present and recommend a blockchain-based platform that can solve all the challenges faced by the existing PLMs. The proposed blockchain-based platform addresses the same purpose as those of the existing PLMs. In addition to the basic features of traditional PLMs, this platform also contains other distinct characteristics, as illustrated in Table 3. Therefore, we strongly recommend it over traditional PLMs for more securely and easily managing product data. Industries can use this platform to more accurately assess their product use, performance, and product maintenance cycles, enabling more intelligent decisions. This may lead to improving the system efficiency in terms of flexibility, optimizing product design, and improving product functions. Moreover, with the ever-increasing need for connectedness and security, the proposed blockchain-based platform provides a framework for organizing and securing the data generated at different phases of the product lifecycle. This work also helps in clarifying how industries exploiting the blockchain method can build a secure and connected production infrastructure.

To conclude, this work highlights and emphasizes the specific challenges with the existing data management systems and recommends a novel blockchain-based solution to overcome those challenges. The recommended solution improves product lifecycle management, and hence plays a vital role in the collaboration process. Finally, the blockchain solution offers versatile capabilities and can be applied in any production industry.

Future work could explore of the existing blockchain-based platform that can be used for product lifecycle management. Moreover, defining the proper criterion and then selecting among the available alternative platforms, using any analytic technique, may be of interest for future contributions.

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Appendix A Quantitative Comparison of Existing PLMs

S. No	PLM Software	Change Mgmt	Design Mgmt	Document Mgmt	Project Mgmt	Product Data Mgmt	Requireme-nts Mgmt	Q and C Mgmt	Supplier Mgmt
1	* Coats Digital	No	Yes	Yes	No	Yes	No	No	Yes
2	* Jama Connect	Yes	No	Yes	Yes	Yes	Yes	Yes	No
3	* SpiraTeam	Yes	No	Yes	Yes	No	Yes	Yes	No
4	* Odoo	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
5	* Jira	Yes	No	Yes	Yes	No	Yes	Yes	No
6	* Airtable	No	No	Yes	Yes	No	Yes	No	Yes
7	* Sage 100 Cloud	No	No	Yes	Yes	No	No	Yes	Yes
8	* Delteck Costpoint	No	No	Yes	Yes	No	No	Yes	Yes
9	* Quip	Yes	No	Yes	Yes	No	Yes	No	Yes
10	* Kinetic	No	No	Yes	Yes	Yes	No	Yes	Yes
11	* CATIA	No	Yes	No	Yes	No	Yes	No	No
12	* MasterControl QE	Yes	Yes	Yes	Yes	No	No	Yes	Yes
13	* Assembla	No	No	Yes	Yes	No	No	Yes	No
14	* Genius ERP	No	No	Yes	Yes	No	No	Yes	Yes
15	* Creo	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
16	* SyteLine	Yes	No	Yes	Yes	No	No	Yes	Yes
17	* Infor M3	Yes	No	Yes	Yes	No	No	Yes	Yes
18	* BlueCherry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
19	* Momentis Fashion Sys	Yes	Yes	Yes	No	Yes	Yes	No	Yes
20	* ProdPad	No	Yes	Yes	Yes	No	Yes	No	No
21	* BlackBelt Fusion	No	Yes	No	No	Yes	No	Yes	Yes
22	* CodeScene	No	No	No	Yes	Yes	Yes	No	No
23	* Exenta	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
24	Arena PLM	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
25	Enovia	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
26	monday.com	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
27	Aha!	Yes	Yes	Yes	Yes	Yes	Yes	No	No
28	Wrike	Yes	No	Yes	Yes	No	Yes	No	Yes
29	Logility	No	Yes	Yes	Yes	No	Yes	Yes	Yes
30	Arbortext	No	Yes	Yes	Yes	Yes	Yes	No	Yes
31	Trello	No	No	Yes	Yes	No	Yes	No	No
32	beCPG PLM	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
33	Space	Yes	No	Yes	Yes	Yes	Yes	No	No
34	PDXpert PLM	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
35	Canny	No	No	No	No	No	No	No	No
36	ClickUp	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
37	FusePLM	Yes	No	Yes	No	Yes	Yes	No	Yes
38	TARA	No	No	Yes	Yes	No	Yes	No	No
39	QM Software	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
40	Trace One PLM	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
41	LaunchDarkly	Yes	No	No	No	Yes	Yes	No	No
42	Infor Visual	Yes	No	Yes	Yes	Yes	No	Yes	Yes
43	NetSuite WMS	Yes	No	Yes	Yes	Yes	No	Yes	Yes
44	Productboard	No	No	Yes	Yes	No	Yes	No	No

S. No	PLM Software	Change Mgmt	Design Mgmt	Document Mgmt	Project Mgmt	Product Data Mgmt	Requireme-nts Mgmt	Q and C Mgmt	Supplier Mgmt
45	Teamcenter	Yes	Yes	No	Yes	No	Yes	Yes	Yes
46	UserVoice	No	No	No	Yes	Yes	Yes	No	No
47	aPriori	No	Yes	No	No	Yes	No	No	Yes
48	Backbone	No	Yes	Yes	No	Yes	Yes	No	Yes
49	Style Arcade	No	Yes	Yes	Yes	Yes	No	No	Yes
50	Craft.io	No	Yes	No	Yes	Yes	Yes	No	No
51	Anvyl	Yes	No	Yes	Yes	Yes	No	Yes	Yes
52	ACE PLM	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
53	One Click LCA	No	Yes	No	Yes	Yes	No	Yes	No
54	ApparelMagic	No	Yes	No	Yes	Yes	Yes	No	Yes
55	Dot Compliance	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
56	SAP PLM	No	No	Yes	Yes	Yes	Yes	Yes	Yes
57	Planview Enterprise	No	No	Yes	No	No	No	Yes	No
58	Chronos	No	No	Yes	Yes	Yes	Yes	Yes	Yes
59	BQUADRO	No	No	Yes	Yes	Yes	No	Yes	Yes
60	Primary	No	Yes	No	No	Yes	Yes	No	No
61	Indigo8	No	Yes	Yes	No	Yes	Yes	No	Yes
62	Surefront	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
63	Autodesk Fusion Lifecycle	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
64	Aras	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
65	Aligni	Yes	Yes	Yes	No	Yes	No	No	Yes
66	Ciiva	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
67	3 Clicks Cloud	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
68	DevSuite	Yes	Yes	Yes	Yes	No	Yes	No	No
69	CMPRO	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
70	SyncForce	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
71	Zdesign	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
72	WFX PLM	No	Yes	Yes	No	Yes	Yes	No	Yes
73	EasyKost	No	Yes	No	Yes	Yes	No	No	Yes
74	PDM Dashboard for JIRA	Yes	No	Yes	Yes	Yes	Yes	No	No
75	STEP	No	No	Yes	No	No	No	No	No
76	ProductCenter	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
77	Centric PLM	Yes	Yes	No	No	Yes	No	Yes	Yes
78	Gatherspace.com	Yes	No	Yes	No	Yes	No	No	No
79	TD/OMS	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
80	Windchill	No	Yes	No	Yes	Yes	No	No	No
81	DevEX	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
82	Optiva	No	No	No	Yes	Yes	No	Yes	No
83	4G: PLM	Yes	Yes	Yes	No	Yes	No	No	Yes
84	Collaborate Cloud	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
85	DesignWin	Yes	No	Yes	Yes	Yes	No	Yes	Yes
86	PowerSteering	Yes	No	Yes	Yes	No	Yes	No	No
87	Prodigy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
88	Propel PLM	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
89	QuadRite	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
90	SourceHUB	Yes	No	Yes	Yes	Yes	Yes	No	Yes

S. No	PLM Software	Change Mgmt	Design Mgmt	Document Mgmt	Project Mgmt	Product Data Mgmt	Requireme-nts Mgmt	Q and C Mgmt	Supplier Mgmt
91	Woises	No	Yes	Yes	Yes	Yes	Yes	No	No
92	ChainReaction	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
93	Lectra Fashion PLM	No	Yes	Yes	No	Yes	Yes	No	Yes
94	Upchain PLM	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
95	YuniquePLM	No	Yes	No	Yes	Yes	No	Yes	Yes
96	DeSL	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
97	VisualNext	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
98	4PACK	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
99	Sopheon Accolade	No	Yes	No	Yes	Yes	No	No	No
100	Actify Centro	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
101	ARG Sourcing	No	Yes	Yes	No	Yes	No	Yes	Yes
102	Aptean PLM	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
103	ARC Facilities	Yes	No	Yes	Yes	Yes	Yes	Yes	No
104	Bamboo Rose	No	No	No	No	Yes	Yes	No	Yes
105	Channel Plus	No	No	Yes	Yes	Yes	Yes	Yes	Yes
106	CIM Database PLM	No	Yes	Yes	Yes	Yes	Yes	Yes	No
107	Collaboration Desktop	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
108	Copy5	No	No	Yes	Yes	Yes	Yes	No	No
109	Duro	Yes	Yes	Yes	No	Yes	No	No	Yes
110	EdgeAX	Yes	Yes	No	No	No	No	No	Yes
111	Emissions Calculator	No	No	Yes	No	No	No	Yes	Yes
112	Factor	No	Yes	Yes	Yes	No	Yes	Yes	Yes
113	iasset.com	No	No	Yes	No	No	No	No	No
114	IFS EAM	No	No	Yes	Yes	Yes	No	Yes	Yes
115	Ignimission Platform	No	No	Yes	No	No	No	Yes	No
116	OpenPDM	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
117	Pattern Design	Yes	Yes	No	Yes	Yes	Yes	No	No
118	PDMPlus	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
119	PLATO SCIO FMEA	Yes	No	Yes	Yes	No	Yes	Yes	No
120	PDM Dashboard	No	No	Yes	Yes	No	Yes	No	No
121	ProEvolve	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
122	ProjectOne	No	No	No	Yes	Yes	Yes	No	No
123	QADEX Vision	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
124	QATrax	Yes	No	Yes	Yes	Yes	No	Yes	No
125	RegulatoryOne	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
126	reINVENT	No	Yes	Yes	Yes	Yes	No	No	Yes
127	Seerene	Yes	No	No	Yes	No	Yes	Yes	Yes
128	SG Benchmarker	Yes	Yes	No	No	Yes	No	No	No
129	Sharp PLM	Yes	No	Yes	Yes	Yes	No	No	No
130	Skyjed	No	No	Yes	No	Yes	No	Yes	Yes
131	SoftExpert PLM Suite	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
132	Specright	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
133	Wave PLM	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
134	Jile	No	No	Yes	Yes	Yes	Yes	Yes	No
135	keytech PLM	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes

* These PLMs provide both on-cloud and on-premises services.

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